Aging of Polyurethane Foams: IR

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INTRODUCTION

Many systems are difficult to study due to their heterogeneity in space - some examples are living systems, emulsions, and foams. Spectromicroscopy allows one to examine regions of the samples on size scales on the order of their heterogeneity. This allows one to see spectral characteristics of the pure components of the sample. Other techniques of sample preparation and study typically yield averaged or potentially compromised data.

We are studying the aging behavior of polyurethane foams. These foams have three different spatial regions - cells filled with gas (~300-700 microns diameter) surrounded by walls (~1 micron and thinner), supported by a structure of wall intersections ("struts" - 10-80 microns across). These foams are structured on a scale small enough that normal methods do not probe the differentiation of composition across the network. There are many high valued systems that use polyurethane foams either as structural elements or as packing/shock adsorbing systems. Understanding the degradation mechanisms will lead to improved materials and improved monitoring of present materials.

We expect that there are several possible degradation processes - those that proceed without the involvement of external chemical agents (migration of polymer components, breaking of the polymer bonds) and external decay (oxidation, hydrolysis, etc.). We are looking for spectral features characteristic of polymer aging - and in particular, we are looking for spatially differentiated characteristics of aging.

We are currently involved in studies using X-ray as well as IR methods at the ALS. We have demonstrated that we can select free standing wall sections that have a varying thickness as indicated by the changing optical interference pattern (figure 1). By taking spectra at locations of various thickness, we can get the surface as verses the bulk contribution to the composition. These results are of useful conjugate nature to the data we have been obtaining via XPS, - Whereas XPS is a surface sensitive tool and probes all of the material on the surface, bulk subtracted IR spectra gives the components on the surface that did not arise from migration perpendicular to the surface.

For example: if we see oxygen on the surface in XPS there are two possible sources - oxidation from gas phase reactants or migration of oxygen containing material (say, surfactant) from the bulk. The IR will only see the first source of oxygen - the second

would not be seen, unless migration occurs along the surface or bulk to a significant fraction of 10 microns (the sampling diameter of the IR beam). Thus IR and XPS studies allow detailed interpretation of the observed spectra.

Our preliminary spectra of unaged foams show no new features in the subtracted spectra, as expected. Our future work will involve investigations of aged foams.

Figure 1 - section of polyurethane foam wall, showing naturally occurring variations in thickness.

This work was supported by the NSF, and was conducted at the Advanced Light Source, supported by the Director, Office of Energy Research, Office of Basic Energy Sciences, Materials Science Division, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098 annd under auspices of DOE Cooperative Agreement
DE-FC08-98NV13410.

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